



Kilopower Reactor Using Stirling Technology (KRUSTY) Nuclear Ground Test Results and Lessons Learned

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KRUSTY Test Objectives



- **Objective 1**: Operate the reactor at steady state with a thermal power output of 4 kW_t at a temperature of 800° C
- **Objective 2**: Verify the stability and load following characteristics of the reactor during nominal and off-nominal conditions
- **Objective 3**: Benchmark the nuclear codes and material cross sections using the test data

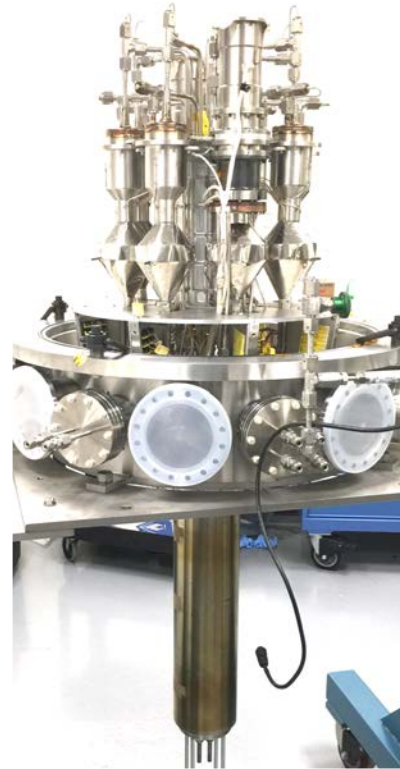
Kilopower Development and the KRUSTY Experiment



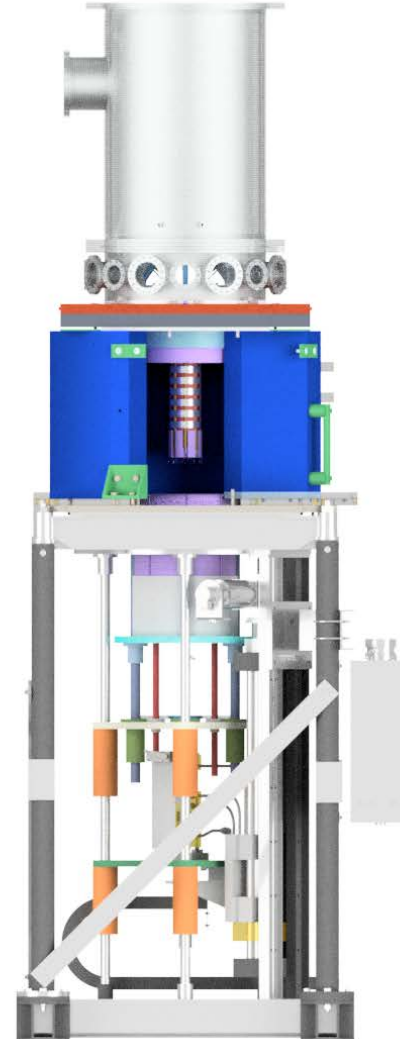
Flight Concept



KRUSTY Design



KRUSTY
Hardware



KRUSTY
Experimental Design



KRUSTY
Experimental
Hardware

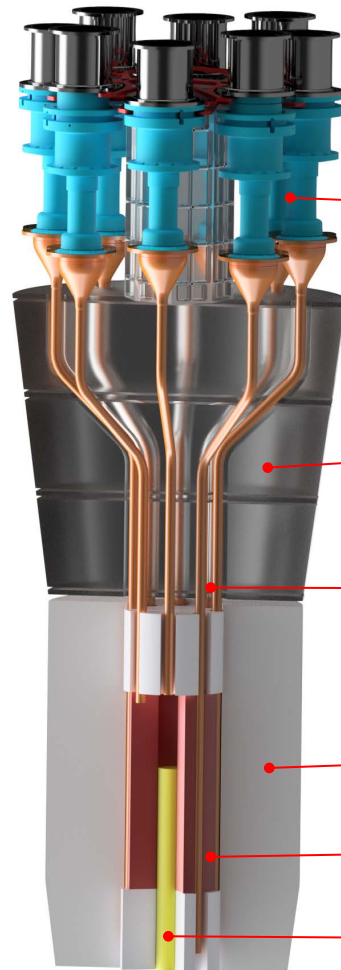


Multi-mission Design

Kilopower 1-3 kWe Multi-Mission vs. KRUSTY Hardware



Multi-mission Design



Stirling Engines
and Balancers

Stirling Thermal
Simulators

Lithium Hydride
Shielding

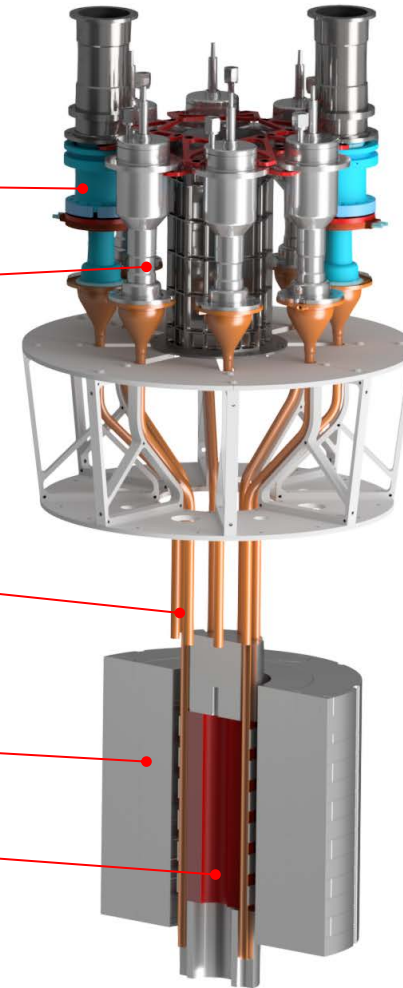
Sodium Heat Pipes

Beryllium Oxide
Reflectors

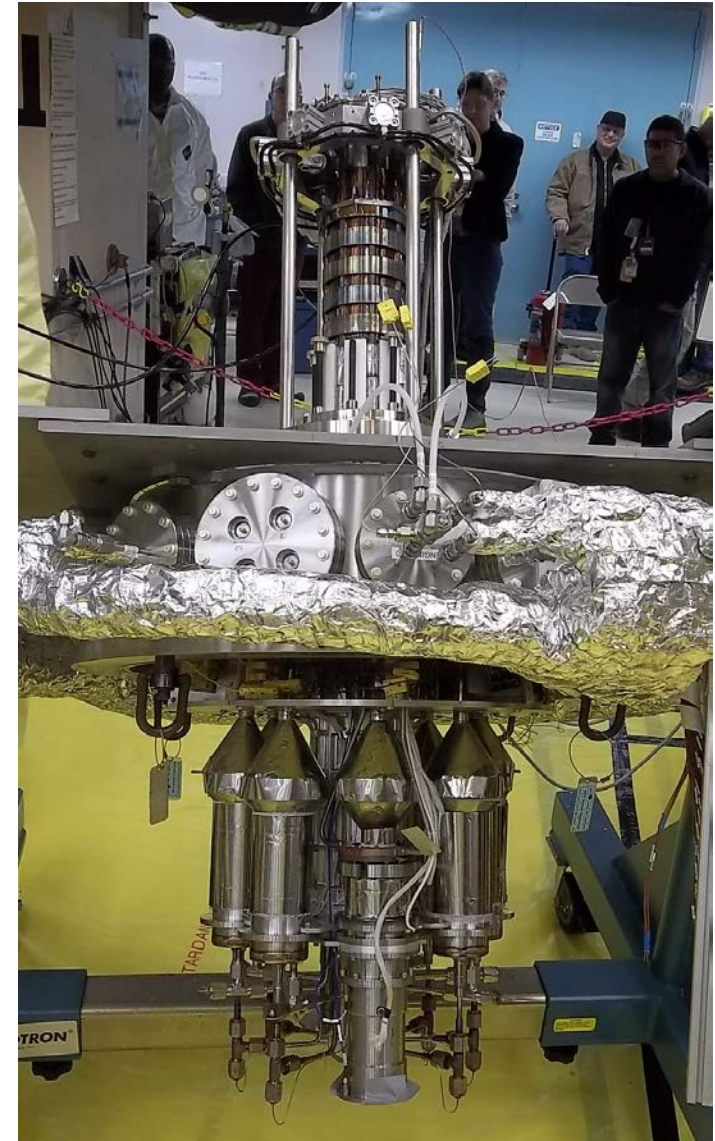
HEU Reactor Core

B₄C Control Rod

KRUSTY Design



Reactor Assembly



Experiment Assembly

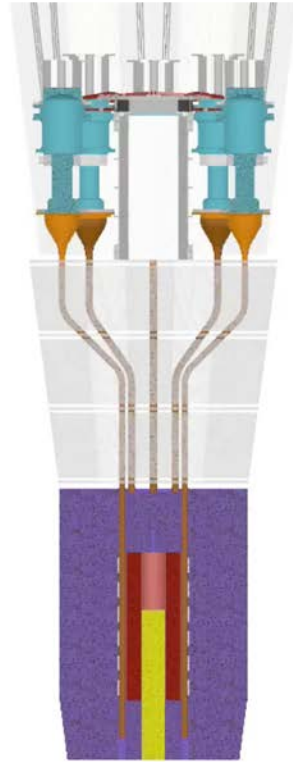




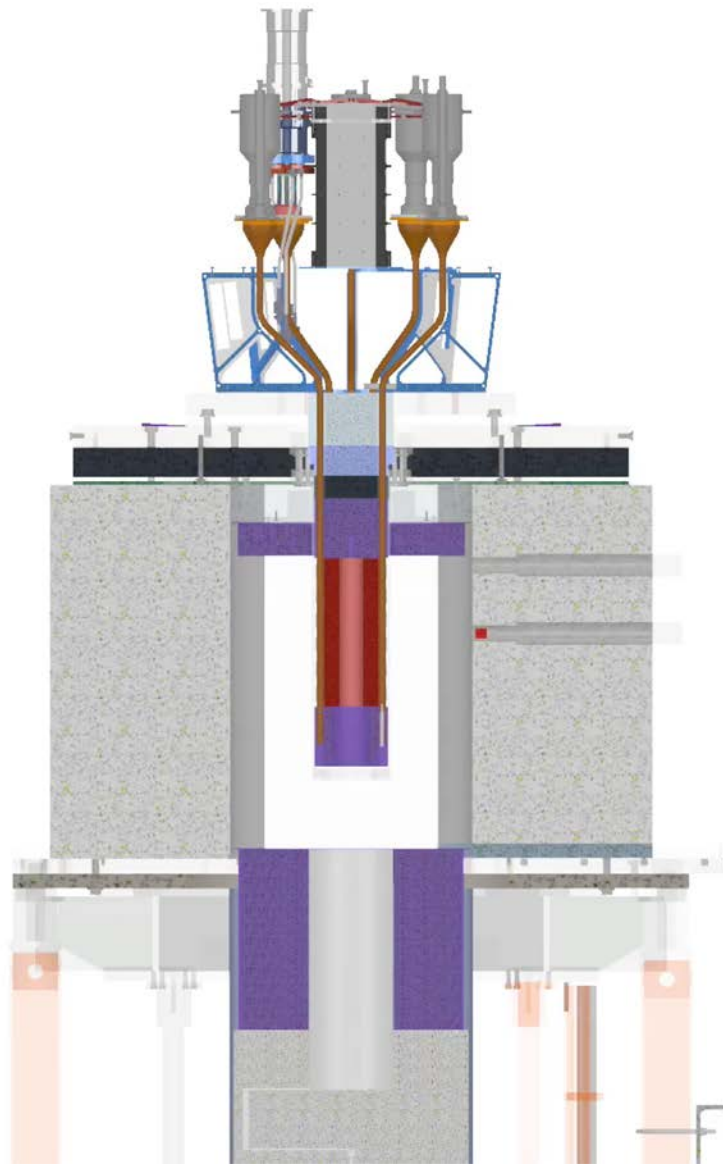
Flight vs. KRUSTY



Flight Unit

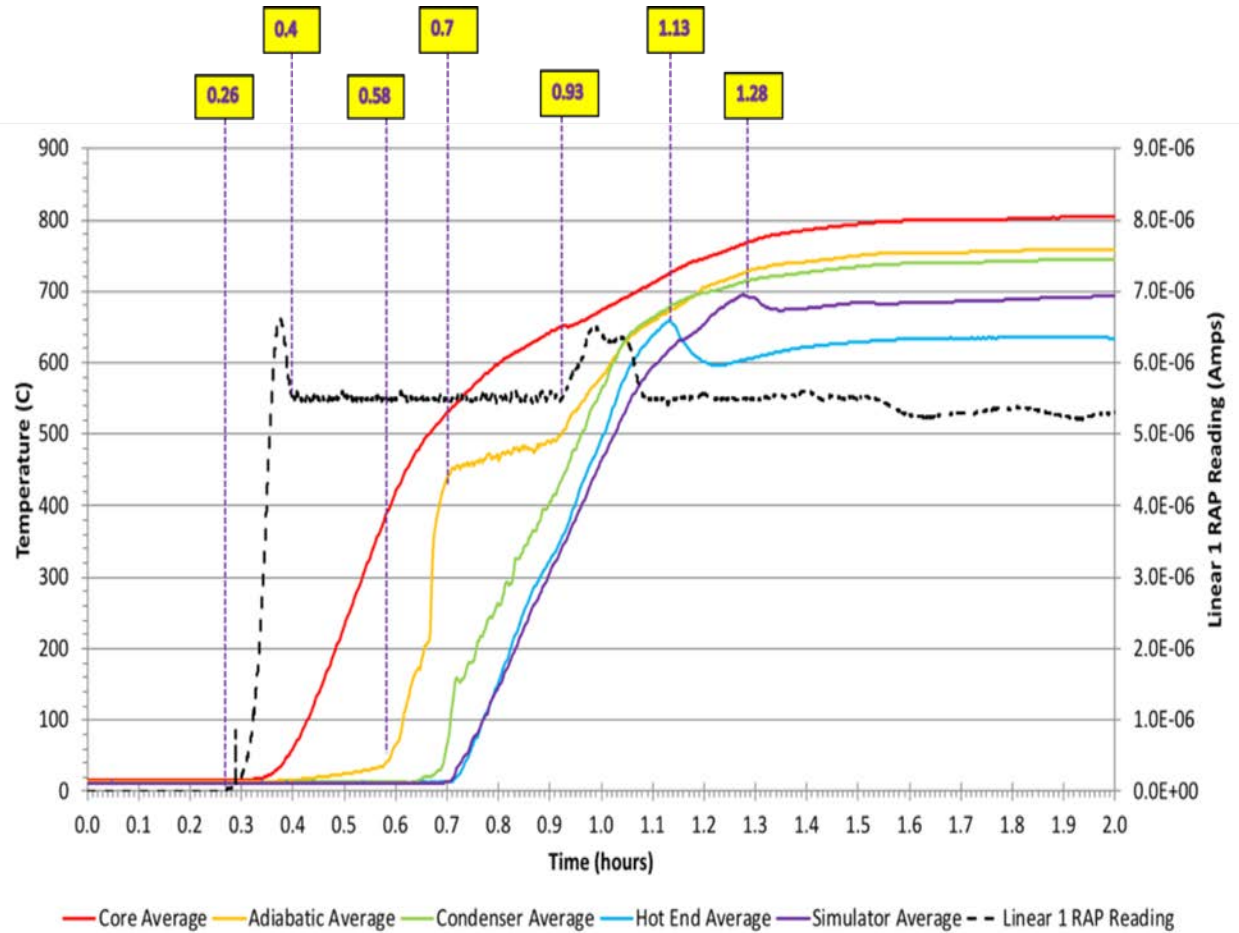
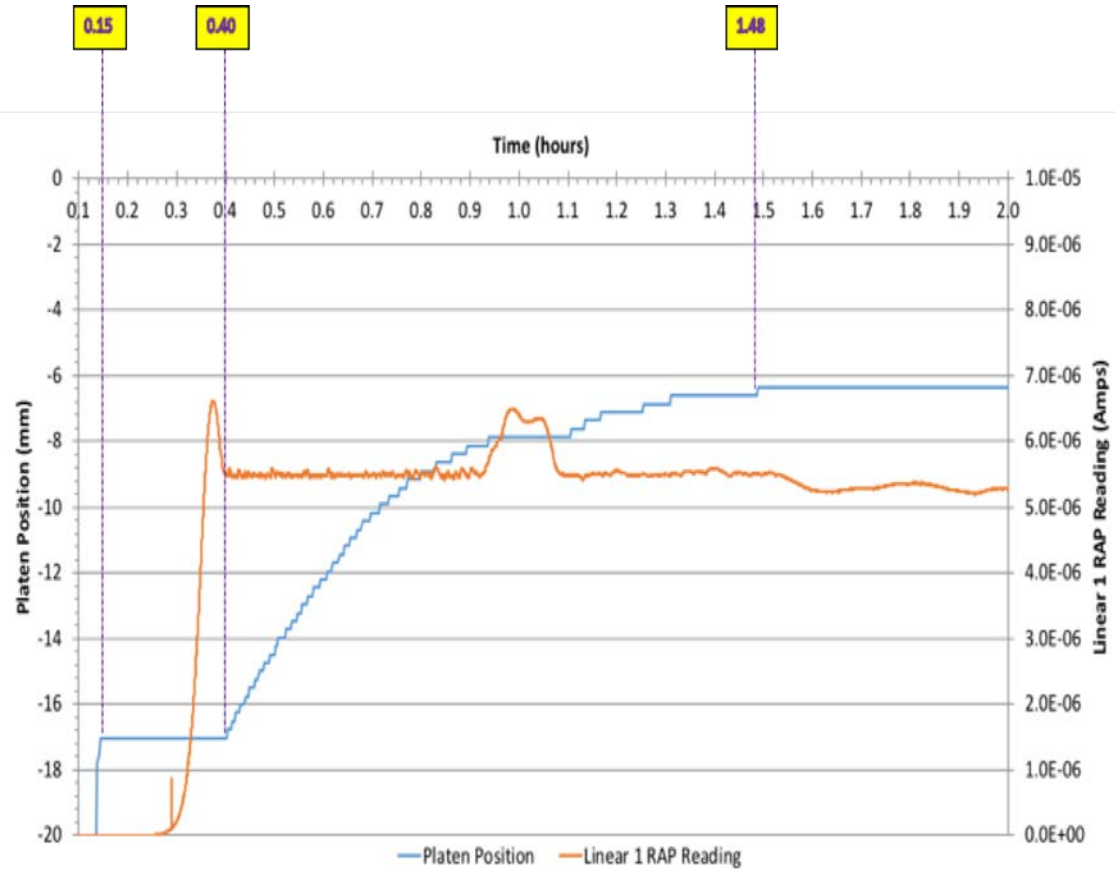


KRUSTY
Experiment



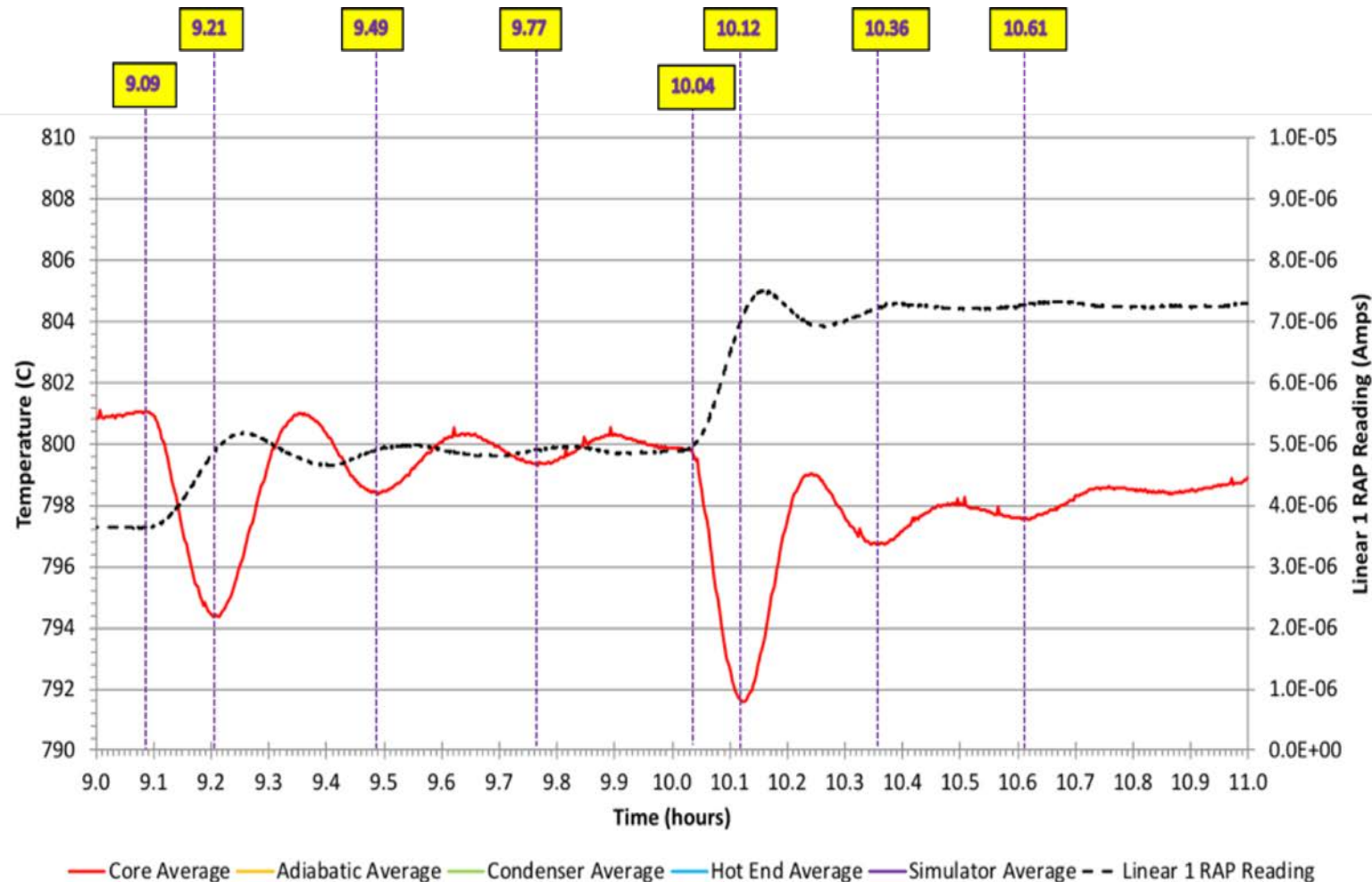


Reactor Startup





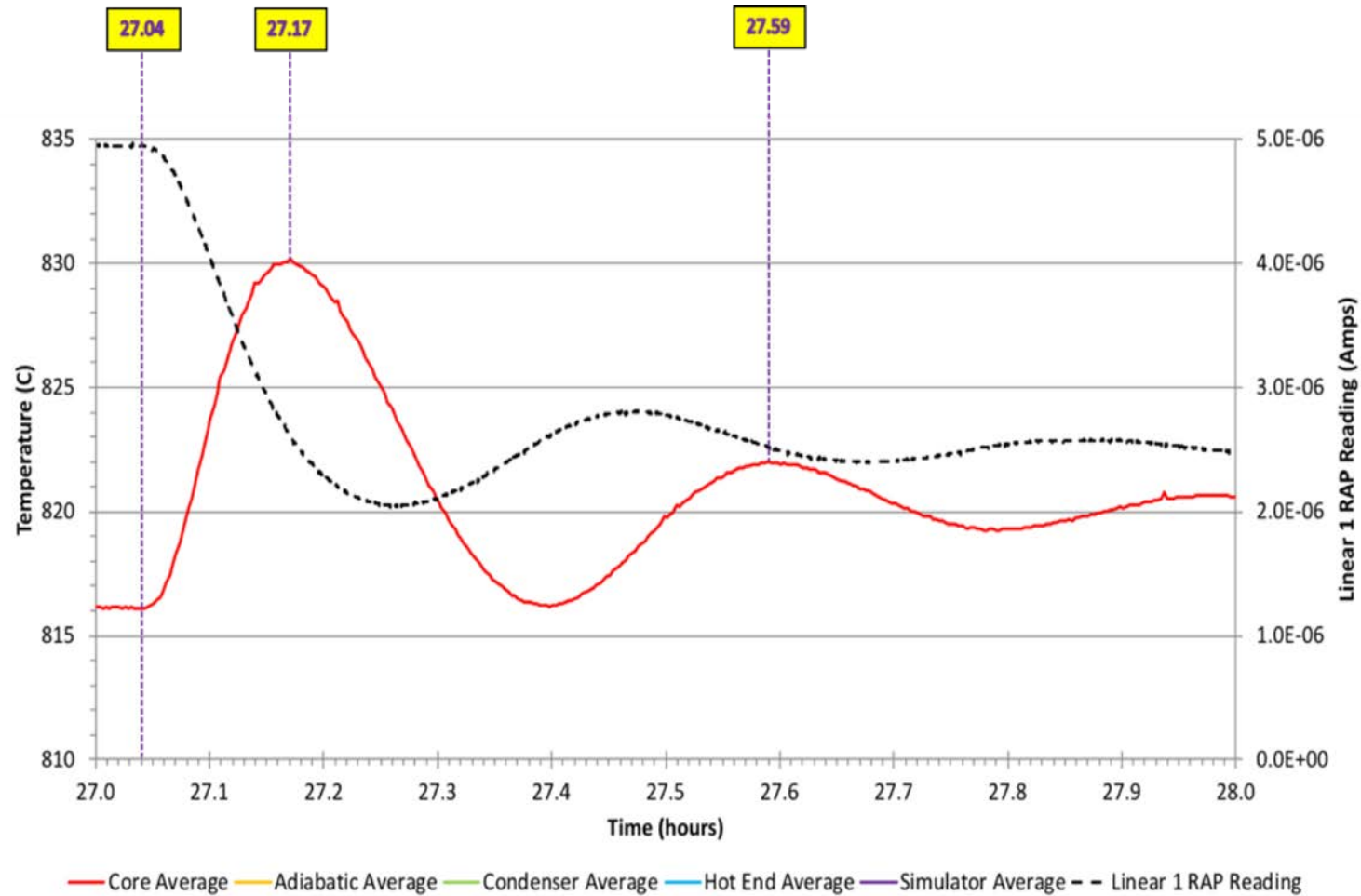
Maximum Thermal Draw



- 10.04 hours: Stirling engines and simulators turned up to maximum thermal draw
- 10.12: core thermal power increases enough to reverse core temperature
- 10.36: First period of oscillation shows controlled dampened response



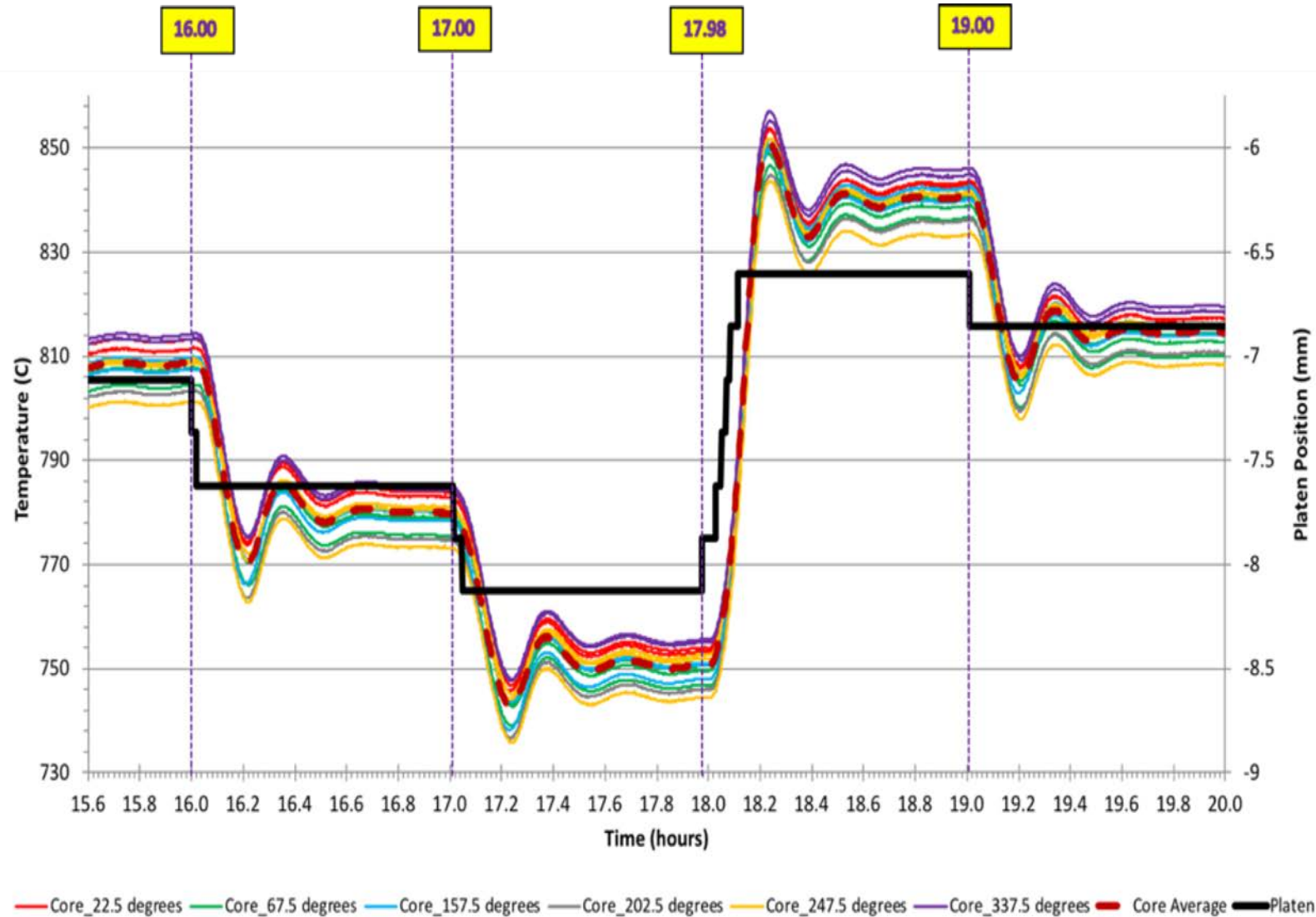
Total Coolant Loss Scenario



- 27.04 hours: Stirling engines and thermal simulators are shut off to simulate worst case reactor coolant loss condition
- 27.17: Local maximum is reached when reactor thermal power decreases to the point where core temperature reverses
- 27.59: First period of oscillation showing damped response converging to steady state

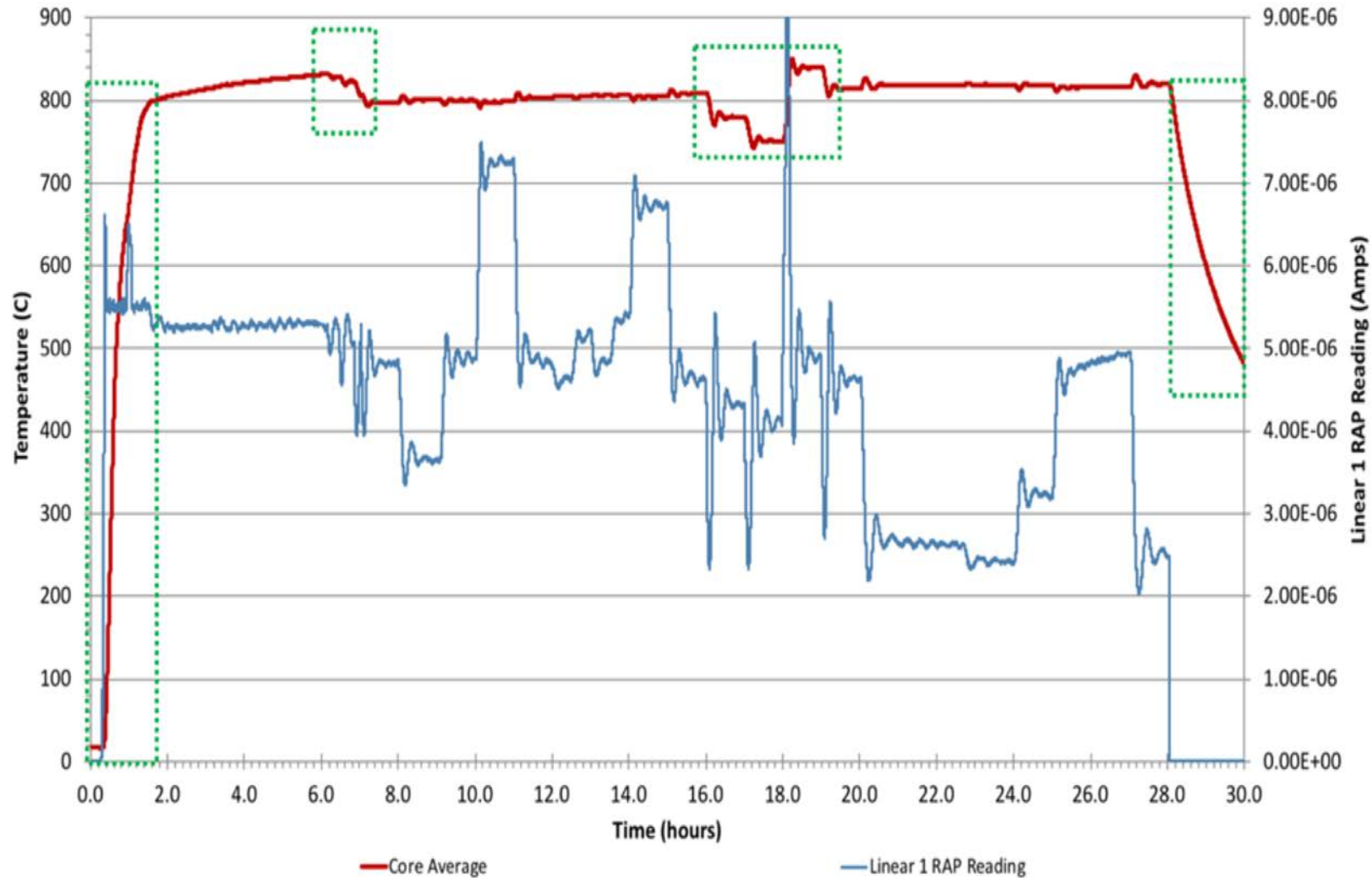


Setting the Reactor Temperature





Overall Performance



KRUSTY Performance Metrics



Event Scenario	Performance Metric	KRUSTY Experiment	Performance Status
Reactor Startup	< 3 hours to 800 deg. C	1.5 hours to 800 deg. C	Exceeds
Steady State Performance	4 kWt at 800 deg. C	> 4 kWt at 800 deg. C	Exceeds
Total Loss of Coolant	< 50 deg. C transient	< 15 deg. C transient	Exceeds
Maximum Coolant	< 50 deg. C transient	< 10 deg. C transient	Exceeds
Convertor Efficiency	> 25 %	> 30 %	Exceeds
Convertor Operation	Start, Stop, Hold, Restart	Start, Stop, Hold, Restart	Meets
System Electric Power Turn Down Ratio	> 2:1 (half power)	> 16:1	Exceeds



Conclusions



- **KRUSTY test complete!!**
 - First real space reactor test in over 50 years
 - Less than 20 million dollars invested
 - Completed in just over 3 years
 - All objectives were met or exceeded
- **What does this mean for NASA?**
 - The ability to move forward towards a flight mission
 - A proven design capable of providing multiple kilowatts of electrical power for several years or decades